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U.S. DEPARTMENT OF AGRICULTURE

Entomology Research Division
Agricultural Research Service
United States Department of Agriculture
in cooperation with
Maryland Agricultural Experiment Station

Field Evaluation of Insecticides for Control of the Alfalfa Weevil in Maryland, 1962-66 [1]

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Steinhauer and coworkers[4] field tested compounds between 1959 and 1961 in Maryland to evaluate their effectiveness against the alfalfa weevil, Hypera postica (Gyllenhal) (Coleoptera: Curculionidae) and other alfalfa insect pests. During these years, heptachlor was uniformly the most effective compound when applied in granular form at the rate of 1 pound of active ingredient per acre to dormant alfalfa in mid-November. However, the development of resistance of the alfalfa weevil to heptachlor[5] and the removal of the compound from Federal registration for this use because of residues in milk[6] left alfalfa producers with less effective chemical protection for the growing alfalfa crop in early spring. The present report summarizes results of the search in Maryland between 1962 and 1966 for more effective chemicals to control the alfalfa weevil.

The chemicals tested are listed at the end of this discussion. Insecticides tested include named materials registered for other crops and thought to be promising for alfalfa weevil control, and numbered candidate materials under development by the various chemical companies. Many of the numbered compounds have never become registered products even though they demonstrated excellent control in field tests. Toxicity, residues, production costs, problems of formulation, and competition are some of the reasons for the failure to proceed with these compounds.

METHODS

The test plots were located at Beltsville, Md., or in fields within 25 miles of Beltsville on the grounds of State institutions. The experiments were arranged in randomized block designs and were replicated a minimum of three times. Plot sizes ranged from 10 by 20 feet to 180 by 200 feet. An untreated check and a standard insecticide were included in all experiments. Heptachlor was the standard insecticide used from 1962 to 1964. A malathion-methoxychlor combination at 1 and 1 1/2 pounds per acre was the standard used in 1965 and 1966. Compounds were either formulated as emulsifiable concentrates (EC) and applied at 12.5 gallons per acre and 40 p.s.i. by a tractor-mounted, power-driven pump sprayer, or they were formulated as granules (G) applied with a 10-foot Gandy® fertilizer spreader. Foliar applications to the first crop were made when 50 to 75 percent of the plant tips showed feeding damage.

The method of evaluating the degree of control achieved changed through the 5 year testing period. Initially, percentage control was based on the number of larvae obtained per sweep in treated plots and in untreated check plots. Loss or damage estimates were considered as an alternate method in 1964. Using this method, two observers independently estimated the percentage of foliage lost to the weevil by visually inspecting plots while walking by or through them. Because foliage loss in treated plots was sometimes negligible, whereas that in untreated check plots was usually almost total, the damage estimates ranged from 0 to 100 percent. The percentage of control for both methods was calculated as follows: $\frac{\text{Untreated - Treated}}{\text{Untreated}}$ x 100. Table 1 shows that visual damage estimates and estimates obtained by the larval sweep method have an average correlation (r) of 0.9597. A high correlation (average r = 0.9696) also exists between the visual damage estimates of two independent observers (table 2). Since visual estimates of damage require much less time than sweeping and counting larvae, the visual method has been used exclusively since 1965 and sweeping is now used only to obtain information about other economic pests. When the newer method is used, damage estimates are made 2 and 3 weeks after treatments have been applied. This would be approximately 1 week and 1 day prior to normal harvest.

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[4] Steinhauer, A. L., Blickenstaff, C. C., and Adler, V. E. Experiments on alfalfa insect control in Maryland. Jour. Econ. Ent. 55: 718-722. 1962.

[5] Adler, V. E., and Blickenstaff, C. C. Resistance of the alfalfa weevil to heptachlor. Jour. Econ. Ent. 57: 299-300. 1964.

[6] Samuels, B. L., and Midyette, J. W., Jr. Heptachlor persistence in the alfalfa production environment. Jour. Dairy Sci. 48: 1101-1105. 1965.

TABLE 1.--Correlation (r) between treatment means for larval sweep counts and visual estimates of foliage damage, 2 weeks after applications of insecticides, Beltsville, Md., 1964

Experiments and dates of application	Number of treatment means	r value
Experiment No. 1, May 2	29	0.9750
Experiment No. 2, May 5	31	.9274
Experiment No. 3, May 8	14	.9768

TABLE 2.--Correlation (r) between visual estimates made by two independent observers of damage caused by the alfalfa weevil to spring-treated alfalfa, Beltsville, Md., 1964

Dates of visual estimates	Number of plots observed	r value
May 15	120	0.9681
May 19	128	.9647
May 22	120	.9699
May 26	128	.9757

RESULTS

Dormant Alfalfa

Relatively poor results were obtained from all fall and early spring applications of insecticides to dormant alfalfa. The use of small contiguous plots for testing purposes may have contributed to the unsatisfactory control levels obtained.[7] Any significant migration of the alfalfa weevil during the winter and early spring from plots with high populations to plots with low populations would tend to reduce effective control at the time of harvest in May or June.

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[7] Steinhauer, A. L., and Blickenstaff, C. C. Fall application of parathion for control of alfalfa weevil. Jour. Econ. Ent. 60: 611-612. 1967.

Fall Applications of Insecticides

The results of fall applications of insecticides to dormant alfalfa are summarized in table 3. Isobenzan was the only named compound (other than heptachlor) that gave 95 to 100 percent control when it was applied at 1/4, 1/2, and 3/4 pounds per acre. However, isobenzan is a hydrocarbon and is too closely related to heptachlor to be acceptable. No other named compound gave 80 percent or more alfalfa weevil control, and no numbered compound gave adequate control up to time of harvest. However, American Cyanamid CL-47470, 2 pounds per acre; Shell SD-7438, 4 pounds per acre; and Virginia Carolina VC 3-670, 1.7 pounds per acre, gave more than 70 percent control at harvest.

TABLE 3.--Effect of insecticides applied in the fall to dormant alfalfa for control of the alfalfa weevil, 1962-65

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
American Cyanamid CL-47470	1964	EC	2	-	-	77	-
American Cyanamid E.I. 47772	1964	EC	2	-	-	67	-
Azinphosethyl	1963	G	1.5	-	-	63	-
	1963	EC	1.5	-	-	63	-
	1964	EC	[2]1.5 +1.5	-	-	74	-
Azinphosmethyl	1964	EC	[2]1.5 + 1.5	-	-	66	-
Azodrin	1965	EC	3	-	66	-	18
EPN	1963	G	2	-	-	42	-
	1963	EC	2	-	-	45	-
	1964	EC	[2]2 + 2	-	-	77	-
Geigy							
GS-12968	1964	EC	3	-	21	-	8
GS-13005	1964	EC	2	-	10	-	0
GS-30494	1962	G	2	-	-	19	-
	1962	G	1	50	-	64	-

See footnotes at end of table.

TABLE 3.--Effect of insecticides applied in the fall to dormant alfalfa for control of the alfalfa weevil, 1962-65--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
GS-30494	1962	EC	2	60	-	51	-
	1962	EC	1	54	-	57	-
	1962	EC	2	-	-	66	-
Heptachlor	1962	G	1	-	-	75	-
	1962	G	1	-	-	99	-
	1963	G	1	-	-	97	-
	1964	G	1	-	-	21	-
Imidan	1962	EC	2	-	-	60	-
	1962	G	2	-	-	42	-
	1962	G	1	-	-	48	-
	1964	EC	4	-	-	79	-
Isobenzan	1962	G	3/4	-	-	95	-
	1963	G	1/4	-	-	99	-
	1963	G	1/2	-	-	100	-
	1963	EC	1/4	-	-	96	-
	1963	EC	1/2	-	-	99	-
Methoxychlor	1962	EC	3	-	-	82	-
	1963	EC	3	-	-	81	-
	1964	EC	[2] 3 + 3	-	-	62	-
	1964	G	[2] 3 + 3	-	-	25	-
	1964	G	6	-	-	0	-
Shell Compound 4072	1964	EC	4	-	-	51	-
Shell SD-7438	1964	EC	4	-	-	83	-
Virginia Carolina VC 3-670	1964	G	1.7	-	-	-	74
	1965	G	2	-	21	-	1
Zinophos	1962	EC	3	-	-	66	-

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[1] EC = emulsifiable concentrate; G = granule.

[2] Materials applied twice in 1964 to the same plots (October 16 and November 12). All other materials were applied only once.

Early Spring Applications of Insecticides

The results of early spring applications of insecticides to dormant alfalfa are summarized in table 4. Niagara NIA-10242 granular at 1 pound per acre gave 82 percent control until harvest. Phorate at 1 1/2 pounds per acre and Virginia Carolina VC 3-670 at 1 pound per acre both maintained at least 77 percent control until 1 week before harvest but did not maintain this level until harvest.

TABLE 4.--Effect of insecticides applied in early spring to dormant alfalfa for control of the alfalfa weevil, 1965-66

Chemical tested	Year tested	Chemical		Control based on foliage damage estimates--	
		Formulation[1]	Active ingredient	1 week before harvest	1 day before harvest
			Pounds per acre	Percent	Percent
Azodrin	1965	EC	1 1/2	13	6
Geigy GS-13005	1965	G	1	29	5
Niagara NIA-10242	1966	G	1	85	82
Parathion	1966	G	1	23	9
Phorate	1966	G	1 1/2	85	53
Virginia Carolina VC 3-670	1965	G	1	77	35

[1] EC = emulsifiable concentrate; G = granule.

First Crop Alfalfa

Individual Insecticides

Results of spring foliar applications of insecticides to the growing crop are summarized in table 5. Among the named compounds applied more than 1 year that gave consistently good results up to the time of harvest were azinphosethyl and azinphosemethyl at 1/2 pound per acre, Imidan at 1/2 to 1 1/2 pounds per acre, methoxychlor at 1 1/4 to 1 3/4 pounds per acre, and phorate at 1/2 to 1 pound per acre. Other promising named compounds included Bidrin at 1 pound per acre, EPN at 2 pounds per acre, isobenzan at 1/16 to 1/4 pounds per acre, methyl demeton at 1 pound per acre, methyl parathion at 1/4 pound per acre, carbaryl at 1 and 2 pounds per acre, dioxathion at 1 1/2 pounds per acre, and Azodrin at 1/2 to 1 pound per acre.

Numbered compounds tested more than 1 year that proved effective were American Cyanamid E.I. 47772 at 1/4 to 3/4 pound per acre, Bay 25141 at 1/4 to 1 1/2 pounds per acre, Bay 39007 at 1 pound per acre, Chipman RP-11974 at 1 pound per acre, Geigy GS-13005 at 1/2 to 3/4 pounds per acre, General Chemical GC-6506 at 1 pound per acre, Hercules 14503 and 14504 at 1 pound per acre, Shell SD-7438 at 1 to 2 pounds per acre, and Virginia Carolina VC 3-670 at 1 pound per acre.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Abate	1964	EC	1/4	19	40	-	13
	1964	EC	1/2	57	76	-	68
	1964	EC	3/4	43	67	-	60
	1964	EC	1	57	82	-	72
	1965	EC	2-3/4	-	99	-	98
	1965	EC	1/2	-	92	-	92
American Cyanamid CL-47470	1963	EC	1/4	98	-	33	-
	1963	EC	1	93	-	46	-
American Cyanamid E.I. 43064	1962	EC	1	97	-	74	-
	1963	EC	1	96	-	40	-
American Cyanamid CL-47031	1964	EC	1	64	84	-	85
American Cyanamid E.I. 47772	1963	EC	1/4	99	-	84	-
	1964	EC	1/8	51	82	-	66
	1964	EC	1/4	67	85	-	83
	1964	EC	3/8	71	91	-	87
	1964	EC	3/4	81	94	-	87
Azinphosethyl	1962	EC	1/2	99	-	85	-
	1962	EC	1	-	-	73	-
	1963	EC	1.5	-	-	63	-
	1964	EC	1/2	82	94	-	93
	1964	EC	1/2	88	85	-	89
	1965	EC	3/4	-	99	-	92
	1966	EC	3/4	95	-	56	-
Azinphosmethyl	1962	EC	1/2	99	-	85	-
	1962	EC	1/2	96	-	70	-
	1964	EC	1/2	71	92	-	88

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Azodrin	1964	EC	1/16	31	76	-	60
	1964	EC	1/2	52	88	-	82
	1964	EC	3/4	68	94	-	90
	1964	EC	1	85	94	-	91
	1965	EC	3/4	98	93	-	95
	1965	EC	1-3/4	-	100	-	98
	1965	EC	1/2	-	98	-	92
	1966	EC	1	-	91	-	96
Bay 25141	1962	EC	1	99	-	79	-
	1963	EC	1/4	94	-	50	-
	1963	EC	1	95	-	34	-
	1964	EC	1	82	93	-	93
	1964	EC	1-1/2	94	92	-	95
	1965	EC	1-1/2	-	99	-	100
	1965	EC	1/4	-	98	-	96
	1966	EC	1/2	-	92	-	93
	1966	EC	1/4	-	84	-	82
Bay 37289	1966	EC	1	-	55	-	47
Bay 39007	1965	EC	1	-	84	-	91
	1965	EC	1/2	-	31	-	73
	1965	EC	1/4	-	4	-	36
	1966	EC	1	-	95	-	99
Bay 41831	1964	EC	1/2	56	83	-	79
	1964	EC	1	72	89	-	86
Bay 45515	1963	EC	1	46	-	53	-
Bay 50282	1964	EC	1/4	49	84	-	80
	1964	EC	3/4	73	91	-	88

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Bidrin	1964	EC	1	74	91	-	90
	1963	EC	1/4	95	-	35	-
Bomyl	1963	EC	1	95	-	39	-
	1965	EC	1/4	-	5	-	29
	1965	EC	1/2	-	53	-	62
	1965	EC	1	-	96	-	60
	1966	EC	1	-	90	-	95
Bromodan	1966	EC	1	-	0	-	0
Carbaryl	1966	S	2	-	92	-	95
	1966	S	1	-	90	-	94
	1966	S	1	93	-	20	-
Chevron RE-5353	1965	EC	1	-	99	-	96
Chipman RP-11974	1965	EC	1	-	97	-	82
	1965	EC	1/2	-	43	-	65
	1965	EC	1/4	-	1	-	1
	1966	EC	1	-	90	-	94
Diazinon	1962	EC	1-1/2	97	-	29	-
	1962	WP	1-1/2	95	-	12	-
	1964	EC	1-1/2	40	72	-	60
	1965	EC	1	-	92	-	71
	1966	EC	1	86	-	0	0
Dimethoate	1962	EC	1/4	98	-	58	-
	1963	EC	1/4	97	-	56	-
	1963	EC	1/4	43	-	77	-
	1963	EC	1/2	91	-	24	-
	1963	EC	1/2	65	-	58	-
	1964	EC	1/2	55	89	-	77

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Dioxathion	1964	EC	1/2	47	79	-	62
	1964	EC	3/4	58	85	-	66
	1966	EC	1-1/2	-	89	-	93
Disulfoton	1966	EC	1	-	54	-	67
EPN	1962	EC	2	-	-	88	-
	1963	EC	2	-	-	45	-
Famphur	1962	EC	1	90	-	70	-
Fenthion	1966	EC	1/2	-	95	-	98
	1966	EC	1	-	92	-	95
Geigy GS-12968	1964	EC	1/16	43	82	-	64
	1964	EC	3/4	87	94	-	91
Geigy GS-13005	1964	EC	1/4	88	94	-	88
	1964	EC	3/4	96	96	-	96
	1965	EC	1/8	-	96	-	94
	1965	EC	1/2	96	97	-	95
	1965	EC	5/8	-	100	-	98
Geigy GS-13798	1966	EC	1	-	94	-	97
Geigy GS-30494	1962	G	1	50	-	64	-
	1962	EC	2	60	-	51	-
	1962	EC	1	54	-	57	-
	1962	EC	2	-	-	66	-
	1962	EC	1-1/2	97	-	88	-
	1962	EC	1	97	-	84	-
	1962	EC	1/2	92	-	76	-
	1962	EC	2	-	-	66	-

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
General Chemical GC-6506	1965	EC	1/4	-	97	-	81
	1965	EC	1/2	-	99	-	92
	1965	EC	1	-	100	-	92
	1966	EC	1	-	95	-	96
Heptachlor	1962	EC	1/4	98	-	82	-
	1962	EC	1/4	97	-	80	-
	1963	EC	1/4	95	-	79	-
	1963	EC	1/4	57	-	33	-
	1964	EC	1/4	26	66	-	78
Hercules 6286	1963	EC	1	94	-	55	-
Hercules 7522	1963	EC	1	87	-	14	-
Hercules 8717	1963	EC	1	79	-	20	-
Hercules 14503	1965	EC	1/4	-	30	-	37
	1965	EC	1/2	-	68	-	56
	1965	EC	1	-	92	-	88
	1966	EC	1	-	89	-	94
Hercules 14504	1965	EC	1/4	-	0	-	0
	1965	EC	1/2	-	85	-	79
	1965	EC	1	-	97	-	87
	1966	EC	1	-	74	-	89
Hooker HRS-1631	1964	EC	3/16	31	17	-	7
	1964	EC	3/4	35	60	-	26
Hooker HRS-1634	1964	EC	5/8	30	55	-	28
	1964	EC	3/4	30	58	-	43

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Imidan	1962	EC	1	97	-	72	-
	1962	EC	2	-	-	60	-
	1962	EC	1/2	92	-	70	-
	1962	EC	1/4	85	-	35	-
	1963	EC	1	99	-	75	-
	1964	EC	1	76	93	-	91
	1964	EC	1/2	88	92	-	90
	1964	EC	1	87	94	-	91
	1964	EC	1-1/2	92	96	-	93
	1965	EC	1	-	99	-	98
	1966	EC	1	96	-	59	-
Isobenzan	1962	EC	1/4	99	-	98	-
	1962	EC	1/8	99	-	94	-
	1962	EC	1/16	98	-	82	-
Isolan	1963	EC	1	91	-	59	-
Malathion	1964	EC	1	61	93	-	86
	1965	EC	1-1/4	91	92	-	94
	1965	EC	1	-	19	-	52
	1965	EC	1/2	-	1	-	2
	1965	EC	1/4	-	0	-	0
	1966	EC	1-1/4	93	-	11	-
	1966	EC	1	-	-	-	74
Metacil	1962	EC	1	64	-	15	-
	1964	EC	1	72	89	-	86
Methoxychlor	1964	EC	1-1/2	82	94	-	91
	1964	EC	3/4	75	90	-	79
	1964	EC	1-1/4	74	92	-	86
	1965	EC	1-3/4	-	87	-	89
	1965	EC	3/4	-	19	-	51

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Methoxychlor	1966	EC	1-1/2	93	-	59	-
	1966	EC	1-1/2	-	-	-	94
Methyl demeton	1964	EC	1	40	84	-	71
Methyl parathion	1966	EC	1/4	-	82	-	92
Mobil MC-A-600	1964	EC	1	61	88	-	64
	1964	EC	1-1/2	87	94	-	86
Monsanto CP-19203	1963	EC	1/4	87	-	29	-
Monsanto CP-40273	1962	EC	1/2	97	-	68	-
Monsanto CP-40294	1962	EC	1/2	95	-	77	-
Monsanto CP-40296	1963	EC	1	94	-	58	-
Niagara NIA-10242	1966	EC	1/4	-	87	-	95
Parathion	1966	EC	1/4	-	65	-	66
Phorate	1964	EC	1/2	68	84	-	80
	1966	EC	1/2	-	92	-	94
	1966	EC	1	-	95	-	97
Shell Compound 4072	1963	EC	1	96	-	78	-
	1964	EC	1	32	76	-	76
	1964	EC	1/2	15	60	-	45
Shell SD-7438	1963	EC	1	84	-	71	-
	1965	EC	1/2	-	26	-	53
	1965	EC	2	-	97	-	98
	1966	EC	1	-	92	-	96

See footnote at end of table.

TABLE 5.--Effect of insecticides applied in spring to growing alfalfa for control of the alfalfa weevil, 1962-66--Continued

Chemical tested	Year tested	Chemical		Control--			
				1 week before harvest based on--		1 day before harvest based on--	
		Formulation[1]	Active ingredient	Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
			Pounds per acre	Percent	Percent	Percent	Percent
Shell SD-8280	1963	EC	1/4	10	-	0	-
	1963	EC	1	57	-	0	-
Shell SD-8530	1963	EC	1	22	-	0	-
Shell SD-8972	1963	EC	1	7	-	0	-
Stauffer N-4543	1966	EC	1	-	93	-	98
Stauffer R-5976	1963	EC	1/4	88	-	64	-
	1963	EC	1	77	-	36	-
Trichlorfon	1964	EC	1	8	61	-	44
Virginia Carolina							
VC 3-668	1965	EC	1/4	-	30	-	81
	1965	EC	1	-	97	-	90
VC 3-670	1963	EC	1	92	-	48	-
	1965	EC	1/4	-	46	-	80
	1965	EC	1/2	-	80	-	84
	1965	EC	1	-	98	-	92
VC 9-104	1965	EC	1	-	88	-	90

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[1] Formulations: EC = emulsifiable concentrate; G = granular; S = sprayable; WP = wettable powder.

Combinations of Insecticides

Results obtained with combinations of insecticides applied as foliar treatments to first-crop alfalfa are summarized in table 6. Methoxychlor plus diazinon and methoxychlor plus malathion at rates of 1 and 1 1/2 pounds per acre gave consistently good control. As mentioned previously, the methoxychlor plus malathion combination is now being used as the standard in all field tests.

TABLE 6.--Effect of insecticides applied in combination to growing alfalfa for control of the alfalfa weevil, 1962-66

Chemical tested	Year tested	Active ingredient	Control--			
			1 week before harvest based on--		1 day before harvest based on--	
			Larval counts	Foliage damage estimates	Larval counts	Foliage damage estimates
		Pounds per acre	Percent	Percent	Percent	Percent
Carbaryl + parathion	1966	1/2 + 1/8	-	55	-	94
Methoxychlor + diazinon	1963	1-1/2 + 1	94	-	61	-
	1964	1-1/2 + 1	80	92	-	90
	1964	1-1/2 + 1	79	94	-	95
	1965	3/4 + 1/2	-	76	-	75
	1965	3/16 + 1/16	0	0	-	15
	1965	1-1/2 + 3/4	-	0	-	87
Methoxychlor + malathion	1963	1-1/2 + 1	97	-	67	-
	1963	1-1/2 + 1	86	-	0	-
	1964	1-1/2 + 1	90	96	-	97
	1964	1-1/2 + 1	80	92	-	72
	1965	1-1/2 + 1	-	95	-	88
	1965	3/4 + 1/2	-	70	-	65
	1966	1-1/2 + 1	-	94	-	98
	1966	1-1/2 + 1	-	-	-	94
	1966	1 + 1	-	94	-	93
	1966	1 + 1	-	-	-	94
	1966	2/3 + 2/3	-	-	-	89
Shell SD-7438+ parathion	1966	1/2 + 1/8	-	92	-	97

Miscellaneous Control Agents

Miscellaneous agents applied as foliar treatments to first crop alfalfa included silica gel; the bacterium, Bacillus thuringiensis var. thuringiensis Berliner; the nematode, DD 136; and various oils and adjuncts combined with azinphosethyl, dimethoate, EPN, Geigy GS-30494, Imidan, methoxychlor, and Zinophos. None of these materials had any significant effect on weevil populations. In most instances the oils and adjuncts actually decreased the effectiveness of the materials with which they were combined. They are mentioned for record purposes only.

SUMMARY

From 1962 to 1966, many insecticides were evaluated for chemical control of the alfalfa weevil. Most of these are still in the experimental stage, are not registered for use on alfalfa, and are no longer of interest commercially. None of the materials applied in the fall to small plots gave effective protection--partly, we now think, because of subsequent reinfestation. The material applied in early spring that showed most promise was Niagara NIA-10242 (granular) at 1 pound per acre (82-percent control at harvest). Named compounds that consistently gave good control when applied to the growing crop during the spring were azinphosethyl, azinphosmethyl, Azodrin, Imidan, methoxychlor, and phorate. Methoxychlor at 1 1/2 pounds per acre plus either diazinon or malathion at 1 pound per acre were the only combinations tested more than 1 year that gave consistently good results. The outstanding numbered insecticides evaluated more than 1 year included American Cyanamid E.I. 47772, Bay 25141 and 39007, Chipman RP-11974, Geigy GS-13005, General Chemical GC-6506, Hercules 14503, Shell SD-7438, and Virginia Carolina VC 3-670.

CHEMICALS EVALUATED

Abate®	*O*,*O*-dimethyl phosphorothioate *O*,*O*-diester with 4,4'-thiodiphenol
American Cyanamid E.I. 43064	cyclic ethylene (diethoxyphosphinothioyl)dithiomidocarbonate
American Cyanamid CL-47031	cyclic ethylene (diethoxyphosphinyl)dithioimidocarbonate
American Cyanamid CL-47470	cyclic propylene (diethoxyphosphinyl)dithioimidocarbonate
American Cyanamid E.I. 47772	cyclic propylene (dimethoxyphosphinyl)dithioimidocarbonate
Azinphosethyl	*O*,*O*-diethyl phosphorodithioate *S*-ester with 3-(mercapto=methyl)-1,2,3-benzotriazin-4(3*H*)-one
Azinphosmethyl	*O*,*O*-dimethyl phosphorodithioate *S*-ester with 3-(mercapto=methyl)-1,2,3-benzotriazin-4(3*H*)-one
Azodrin®	3-hydroxy-*N*-methyl-*cis*-crotonamide dimethyl phosphate
Bay 25141	*O*,*O*-diethyl *O*-[p-(methylsulfinyl)phenyl]-phosphorothioate
Bay 37289	*O*-ethyl *O*-2,4,5-trichlorophenyl ethylphosphonothioate
Bay 39007	*o*-isopropoxyphenyl methylcarbamate
Bay 41831	*O*,*O*-dimethyl *O*-4-nitro-*m*-tolyl phosphorothioate
Bay 45515	*O*,*O*-dimethyl *O*-*m*-nitrophenyl phosphorothioate
Bay 50282	methyl-,4-(diallylamino)-3,5-xylyl methylcarbamate
Bidrin®	3-hydroxy-*N*,*N*-dimethyl-*cis*-crotonamide dimethyl phosphate
Bomyl®	dimethyl 3-hydroxyglutaconate dimethyl phosphate
Bromodan	1,2,3,4,7,7-hexachloro-2-norbornene
Carbaryl	1-naphthyl methylcarbamate
Chevron RE-5353	*m*-(1-methylbutyl)phenyl methylcarbamate
Chipman RP-11974	*O*,*O*-diethyl phosphorodithioate *S*-ester with 6-chloro-3-(mercaptomethyl)-2-benzoxazolinone
Diazinon	*O*,*O*-diethyl *O*-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorodithioate

Dimethoate	*O*,*O*-dimethyl *S*-(*N*-methylcarbamoylmethyl) phosphorodithioate
Dioxathion	*p*-dioxane-2,3-diyl ethyl phosphorodithioate
Disulfoton	*O*,*O*-diethyl *S*-[2-(ethylthio)ethyl] phosphorodithioate
EPN	*O*-ethyl *O*-*p*-nitrophenyl phenylphosphonothioate
Famphur	*O*,*O*-dimethyl *O*-[*p*-(dimethylsulfamoyl) phenyl] phosphorothioate
Fenthion	*O*,*O*-dimethyl *O*-[4-(methylthio)-*m*-tolyl] phosphorothioate
Geigy GS-12968	*O*,*O*-dimethyl phosphorodithioate *S*-ester with 2-ethoxy-4-(mercaptomethyl)-Δ^2-1,3,4-thiadiazolin-5-one
Geigy GS-13005	*O*,*O*-dimethyl phosphorodithioate *S*-ester with 4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one
Geigy GS-13798	2-methyl-8-quinolyl methylcarbamate
Geigy GS-30404	*S*-[[(2,5-dichlorophenyl)thio]methyl] *O*,*O*-dimethyl phosphorodithioate
General Chemical GC-6506	dimethyl *p*-(methylthio)phenyl phosphate
Heptachlor	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene
Hercules 6286	*O*,*O*-diethyl phosphorodithioate *S*-ester with 3-(mercaptomethyl)-2-benzoxazolinone
Hercules 7522	6-chloro-*m*-cumenyl methylcarbamate
Hercules 8717	*m*-(2-propynyloxy)phenyl methylcarbamate
Hercules 14503	*O*,*O*-diethyl phosphorodithioate *S*-ester with *N*-(2-chloro-1-mercaptoethyl)phthalimide
Hercules 14504	*O*,*O*-dimethyl phosphorodithioate *S*-ester with *N*-(2-chloro-1-mercaptoethyl) phthalimide
Hooker HRS-1631	methyl-*o*-[1-(methoxymethyl)allyl]phenyl methylcarbamate
Hooker HRS-1634	*O*,*O*-dimethyl 3-9-thiabicycle [4.2.1] nonenyl phosphorodithioate
Imidan®	*O*,*O*-dimethyl *S*-phthalimidomethyl phosphorodithioate
Isobenzan	1,3,4,5,6,7,8,8-octachloro-1,3,3a,4,7,7a-hexahydro-4,7-methanoisobenzofuran

Isolan®	1-isopropyl-3-methylpyrazol-5-yl dimethylcarbamate
Malathion	S-[1, 2-bis (ethoxycarbonyl)ethyl] O,O-dimethyl phosphorodithioate
Metacil®	4-(dimethylamino)-m-tolyl methylcarbamate
Methoxychlor	1,1,1-trichloro-2,2-bis(p-methoxyphenyl)ethane
Methyl demeton	mixture of O,O-dimethyl S(and O)-[2-(ethylthio)ethyl] phosphorothioates
Methyl parathion	O,O-dimethyl O-p-nitrophenyl phosphorothioate
Mobil MC-A-600	benzo [b]thien-4-yl methylcarbamate
Monsanto CP-19203	O-methyl,S-phosphonodithioate with 2-mercapto-N-methyl=acetanide
Monsanto CP-40273	O-p-nitrophenyl O-propyl methylphosphonothioate
Monsanto CP-40294	O-p-nitrophenyl O-phenyl methylphosphonothioate
Monsanto CP-40296	O-4-chlorobutyl O-(alpha,alpha,alpha-trifluoro-4-nitor-m-tolyl) methylphosphonothioate
Niagara NIA-10242	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate
Parathion	O,O-diethyl O-p-nitrophenyl phosphorothioate
Phorate	O,O-diethyl S-[(ethylthio)methyl] phosphorodithioate
Shell Compound 4072	2-chloro-1-(2,4-dichlorophenyl) vinyl diethyl phosphate
Shell SD-7438	S-benzylidene O,O-dimethyl phosphorodithioate
Shell SD-8280	2-chloro-1-(2,4-dichlorophenyl)vinyl dimethyl phosphate
Shell SD-8530	3,4,5-trimethylphenyl methylcarbamate
Shell SD-8972	1-(4-bromo-2,5-dichlorophenyl)-2-chlorovinyl dimethyl phosphate
Stauffer N-4543	O-isobutyl ethylphosphonodithioate S-ester with N-(mer=captomethyl)phthalimide
Stauffer R-5976	2-[(mercaptomethyl)thio]ethyl methylcarbamate S-ester with O,O-dimethylphosphorodithioate
Trichlorfon	dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate
Virginia Carolina VC 3-668	O-methyl S,S,dipropyl phosphorotrithioate
Virginia Carolina VC 3-670	dipropyl methylphosphonotrithioate
Virginia Carolina VC 9-104	O-ethyl S,S-dipropyl phosphorodithioate
Zinophos®	O,O-diethyl O-2-pyrazinyl phosphorothioate